Cassini Mission Gravity-Assist (Swingby)

WHAT IS A GRAVITY-ASSIST SWINGBY

Interplanetary space missions can be launched only at certain times. These "windows of opportunity" are called launch periods. They are dependent upon both the relative positions of Earth and the target planets, and the capabilities of the available launch vehicles. The primary launch period for Cassini, based on the alignment of the planets and the capabilities of the Titan IV/Centaur launch vehicle, is in October 1997. The launch would boost the Cassini spacecraft (i.e., the orbiter and the Huygens probe) into a Venus-Venus-Earth-Jupiter Gravity-Assist (VVEJGA) trajectory toward its final destination at Saturn (see Figure 1).

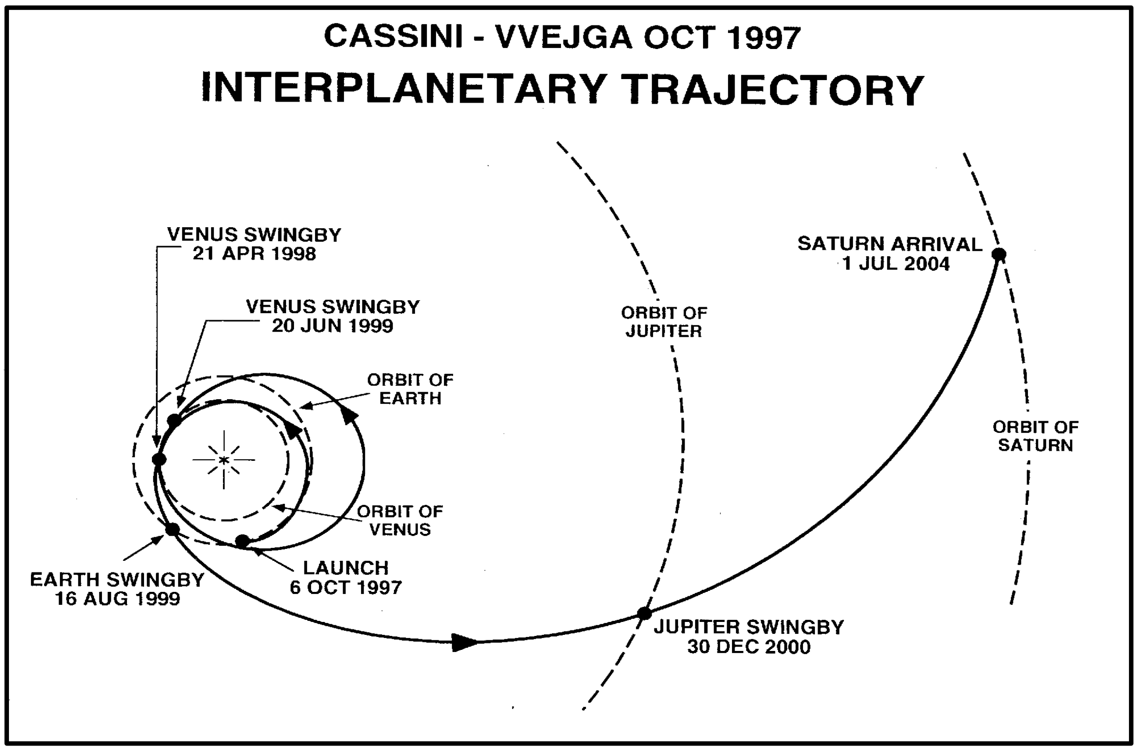

Figure 1. Cassini Trajectory

The reason why the VVEJGA trajectory is necessary is because a direct trajectory from Earth to Saturn is not feasible for the Cassini mission. Existing launch vehicles do not provide enough thrust to take the spacecraft directly to its destination.

Planetary gravity-assists change a spacecraft's speed and direction when the spacecraft encounters a planet's gravitational field, and reduces the launch energy requirements and allows launch of the spacecraft with existing technology—in this case a Titan IV/Centaur rocket.

When the spacecraft arrives at Saturn it will take extensive observations and measurements over a four-year period to fulfill the mission's science objectives.

GRAVITY-ASSIST (SWINGBY) HISTORY

Gravity-assists, or swingbys, represent a key achievement that has made the exploration of our solar system possible. Swingbys have been used since the 1973 Mariner 10 mission, which flew by Venus on the way to Mercury. Since then, swingbys have been used successfully on many planetary missions, including Pioneer 11 to Saturn, Voyagers 1 and 2 to the outer planets, Galileo to Jupiter, and Ulysses to the Sun.

Perhaps most spectacular of all, the Voyager 2 spacecraft executed three planetary swingbys (of Jupiter, Saturn, and Uranus) on the way to its encounter with Neptune in August 1989. Then, after reaching Neptune, Voyager 2 conducted a swingby of that planet in order to gain the momentum and trajectory that would send the spacecraft out of the solar system, its final goal. Programming the trajectory past Neptune required a precise estimation of the planet's mass and its distance from Earth. The maneuver was executed flawlessly, and Voyager 2 is now searching for the heliopause, or the predicted boundary of the solar system and interstellar space.

More recently, the much larger Galileo spacecraft needed one swingby of Venus and two swingbys of Earth in order to acquire enough energy to reach Jupiter. Unlike Voyager's swingby of Neptune, which required the estimation of the planet's position and mass, the Galileo swingbys of Earth were calculated much more precisely, since the location and mass of the Earth are well known. In its first swingby of Earth in December 1990, Galileo came within 8 km (5 miles) of its intended 1000 km (600 miles)-high aimpoint above the Earth. In its December 1992 swingby, Galileo came within 2 km (1 mile) of its 300 km (186 miles)-high aimpoint.

POSSIBILITY OF INADVERTENT EARTH REENTRY

The Cassini mission and spacecraft have been designed so that there is less than a one in one million chance of an inadvertent atmospheric reentry accident during the Earth swingby. The Jet Propulsion Laboratory conducted an extensive analysis to assess the probability of an Earth reentry accident and to determine design strategies and measures that would best prevent such an event from happening. Actions taken include adding extra spacecraft micro-meteoroid shielding and raising the minimum Earth swingby altitude from 300 km (186 miles) to at least 500 km (310 miles).

The spacecraft trajectory is specifically designed to avoid Earth's atmosphere. The trajectory is biased 5000 km (3106 miles) or more away from the swingby altitude (not less than 500 km) for all but 10 days prior to the swingby. The possibility of an Earth reentry only becomes conceivable if an extremely unlikely sequence of events and failures occurs. The vast majority of potential spacecraft failures do not alter the spacecraft's trajectory. To initiate an impact trajectory, a failure would have to cause a change in the spacecraft's velocity of exactly the right magnitude and direction. For this reason, it is extremely unlikely that a misfire of the Cassini rocket system would result in an inadvertent Earth reentry. Another fact to keep in mind is that a number of spacecraft maneuvers will have to be successfully conducted just to bring the spacecraft within tens of thousands of kilometers of Earth. A maneuver at 10 days before swingby will ensure that the spacecraft arrives at the desired point in space for the gravity-assist but does not come closer to Earth than 500 km.

SUMMARY

Cassini's Earth swingby will follow numerous successful gravity-assists conducted during the long and unique history of our nation's space program. The chance of a Cassini Earth reentry is less than one in a million.

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